Cognitive Modeling of Collaboration in Various Contexts

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Outline

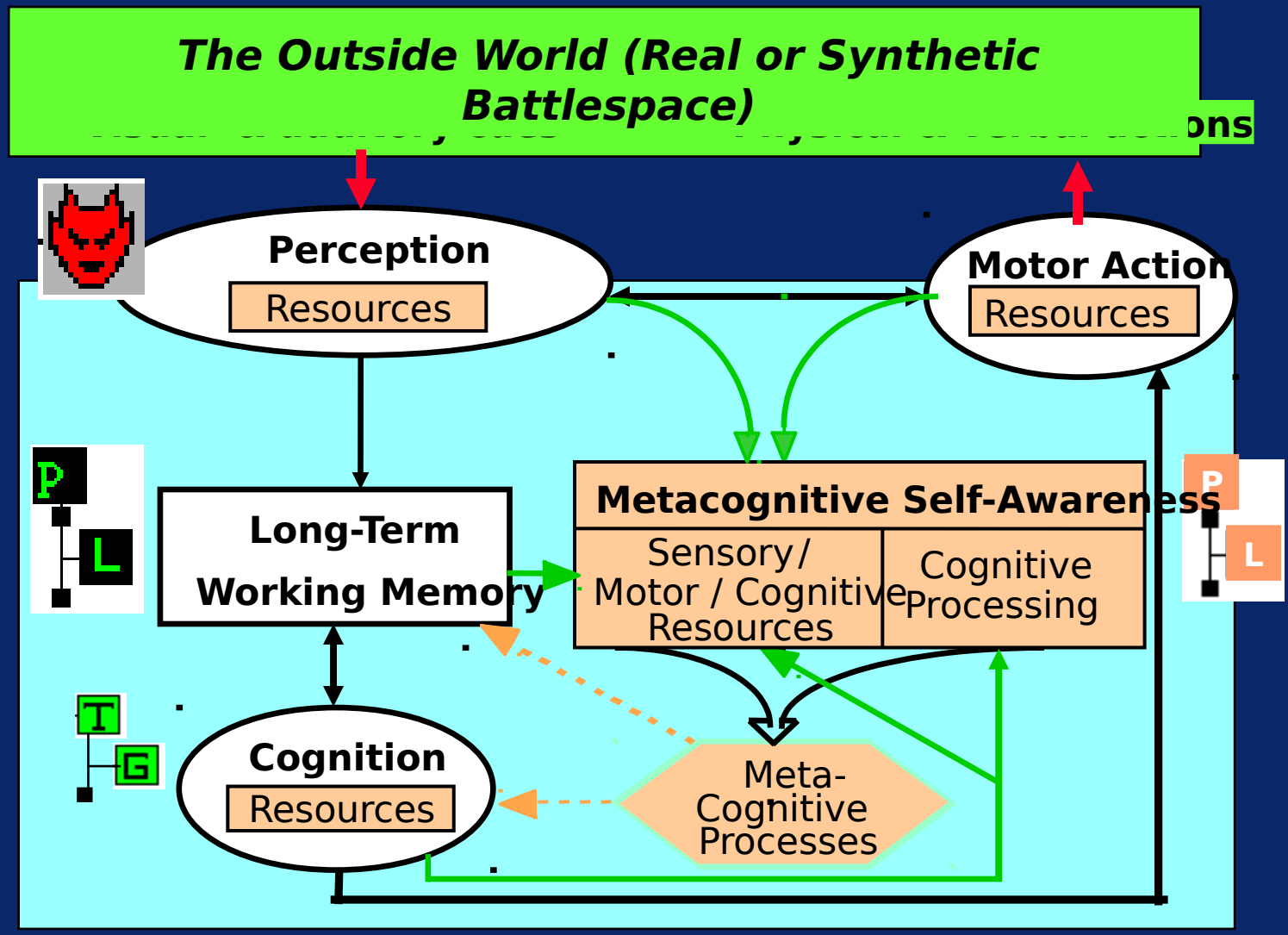
- Overview of modeling cognitive bases of collaboration
- Introduction to the COGNET cognitive architecture
- Methodology for cognitive modeling
- Example applications and lessons learned for modeling cognitive bases of collaboration
- A tentative reference architecture for models of cognitive bases of collaboration
- Conclusions

Modeling Collaboration

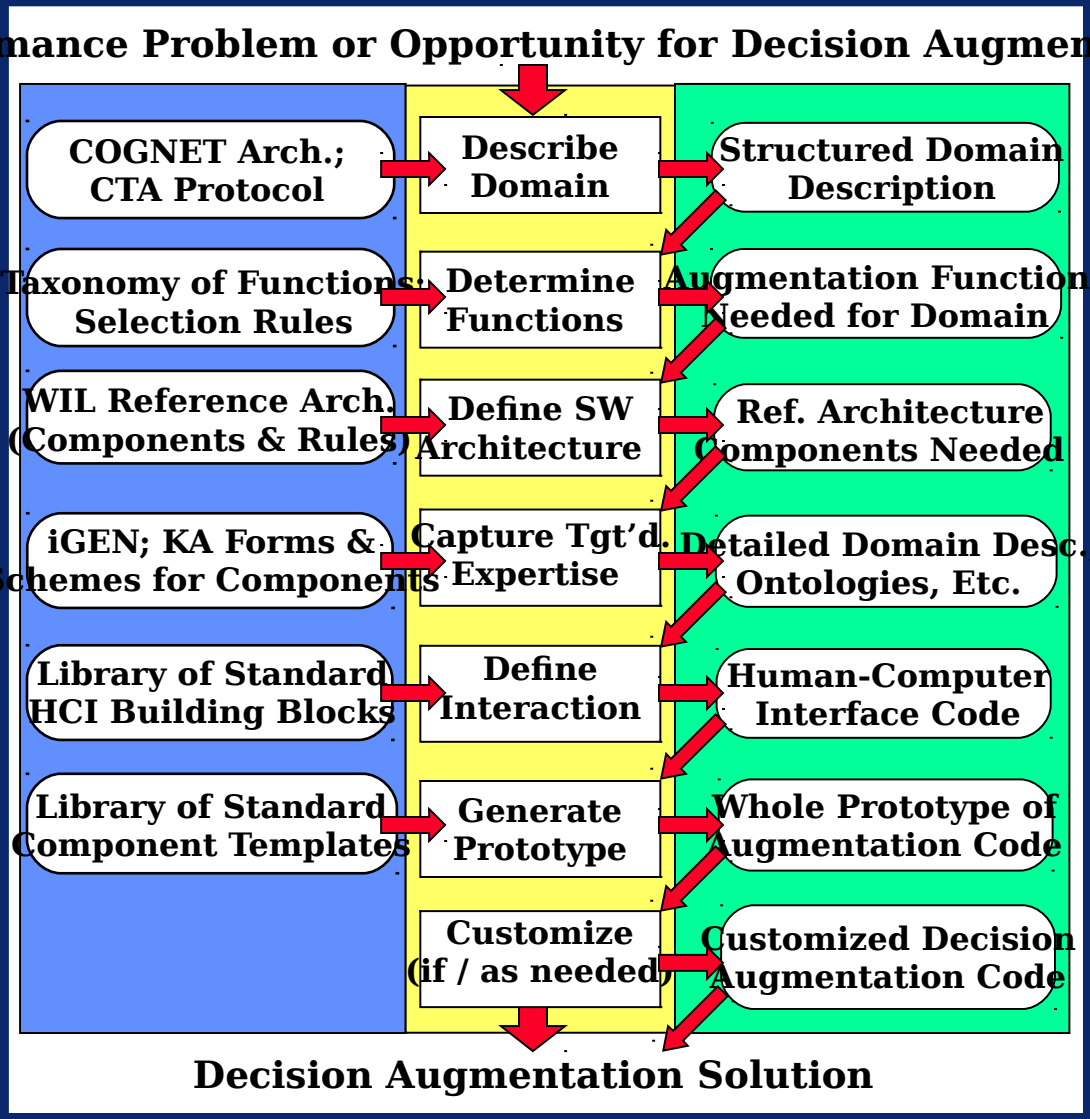
Many different ways of looking at collaboration, from many diverse points of view.

- **Focus: modeling cognitive bases of collaboration**
  - **Cognitive processes of collaborators**
  - **Representations of knowledge for use by those processes**
  - **Communicative processes used by collaborators**
  - **Impact of context on collaboration**
  - **Putting it all together to generate collaboration**
- **Methods used**
  - **COGNET Cognitive Architecture and Methodology**
  - Zachary, W., Ryder, J., & Hicinbothom, H. (2000). Building Cognitive Task Analyses and Models of a Decision-Making Team in a Complex Real-Time Environment. In J.M.C. Schraagen, S. F. Chipman, & V. L. Shalin (Eds.), Cognitive Task Analysis Mahwah: Lawrence Erlbaum Associates, Inc.
- **Tools used for cognitive modeling**
  - **iGEN cognitive agent software development toolkit, including software implementation (BATON) of COGNET architecture**

The COGNET Cognitive Architecture



The COGNET Method Updated for Work-centered Infomediary Layer


Performance Problem or Opportunity for Decision Augmentation
Tools, Data, Design Knowledge
Intermediate Products of Steps
COGNET Arch.; CTA Protocol
Describe Domain
Structured Domain Description
Taxonomy of Functions; Selection Rules
Determine Functions
Augmentation Functions Needed for Domain
WIL Reference Arch. (Components & Rules)
Define SW Architecture
Ref. Architecture Components Needed
iGEN; KA Forms & Schemes for Components
Capture Tgt'd. Expertise
Detailed Domain Desc., Ontologies, Etc.
Library of Standard HCI Building Blocks
Define Interaction
Human-Computer Interface Code
Library of Standard Component Templates
Generate Prototype
Whole Prototype of Augmentation Code
Customize (if / as needed)
Customized Decision Augmentation Code
Decision Augmentation Solution

Modeling Collaboration: Example Applications

- Models to better understand dangerous decision making -- TADMUS and FAA
- Models as expert operators -- AET
- Models as synthetic team members and instructors -- SYNTHERS and SCOTT
- Future: Collaborating with students, instructors, and bosses -- PSYNTHIA

TADMUS & FAA: Models to Understand Decision-Making

- **Problem:**
  - For USN: Teamwork and decision-making while under stress
    - Example: USS Stark Incident (mine)
    - Example: USS Vincennes / Iranian Airbus (shooting)
  - For FAA: Air Traffic Controller training
- **Solution:**
  - Cognitive Task Analysis to produce analytic Cognitive Models
- **Lessons Learned about Modeling Collaboration:**
  - Team members rely on situational cues and communications
    - Each team member ‘knows about’ roles of others
    - No explicit mental model of other team members’ thoughts
    - Expertise includes expectations about patterns of team communications, not just patterns of ‘external’ cues
  - Intra-team communications essential to situation awareness
  - Good team situation awareness (SA) and pre-planned responses lead to best performance by individuals and team

AET: Models as Test Answer Keys

- **Problem:**
  - For USN: Team training is too costly and personnel intensive
- **Solution:**
  - Advanced Embedded Training (AET) System
    - Executable software (cognitive agents) from expert models
    - Context-sensitive expert behavior as expected actions
    - Compare observed actions to expected actions
- **Lessons Learned about Modeling Collaboration:**
  - Expert individual watchstander model can be constructed to do extremely complex, difficult, dangerous jobs
  - Expert model of individual might participate in team via:
    - Information exchange (use all sources; pass info; SitReps)
    - Communication (phraseology; completeness; brevity; but clarity [-] is still quite a challenge for a computer)
    - Supporting behavior (team errors; backup assistance)
    - Initiative/leadership (guidance/suggestions [-]; priorities)

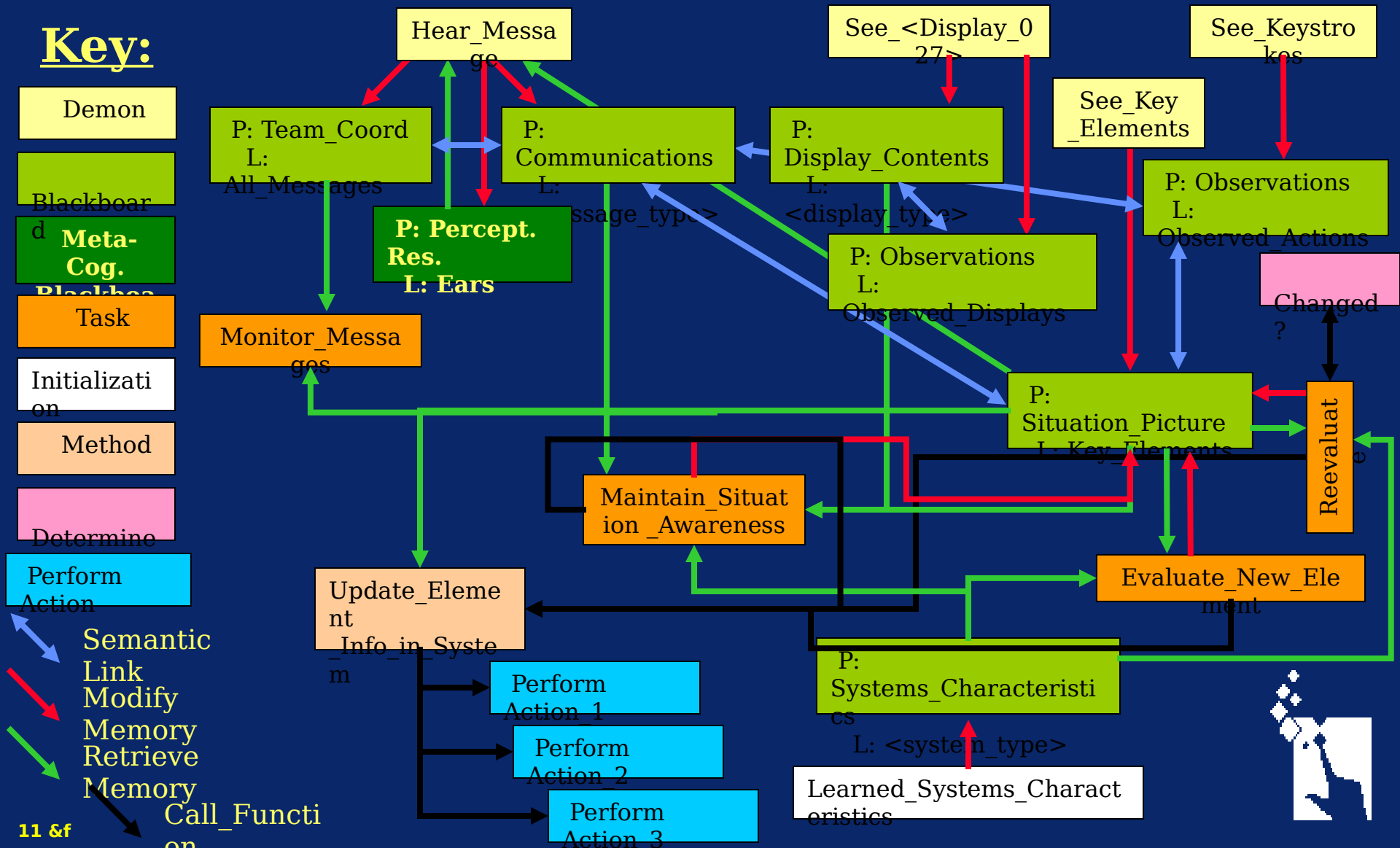
SYNTHERs & SCOTT: Models as Synthetic Team Members

- **Problem:**
  - Need whole team to be able to train even a few team members.
- **Solution:**
  - Synthetic Team Members (SYNTHERs) available 24 x 7 x 365
  - Synthetic Cognition for Operational Team Training (SCOTT)
- **Lessons Learned about Modeling Collaboration:**
  - Meta-cognitive self-awareness enhances believability
    - Explicitly model perceptual (auditory) control and usage
    - Explicitly model motor action (vocal apparatus) control/use
    - Better means of representing intra-team communication and cooperation
  - Built on successes in modeling communication in AET
  - Differences in means of perception between software and humans can still lead to disconnects that seem odd to people

PSYNTHIA: Collaborating with Students, Instructors, & Bosses

- **Problem:**
  - Affordable training of individuals for team jobs
  - Different instructors for different training opportunities / exercises
  - Reduce time-to-competence and get warfighters afloat faster
- **Solution:**
  - Integrate and Operationalize Prior Lessons Learned
  - Personal Synthetic Instructional Agent (PSYNTHIA)
    - Fill in gaps between exercises and between instructors
    - Enable local and remote collaboration
      - Human-Agent (instruction; testing; secure reporting & direction)
      - Human-Agent-Human (computer-mediated distance instruction)
      - Dynamic construction of graphical / textual interaction
      - On-the-fly scenario generation and presentation
    - Cross boundary between ashore and afloat training
- **Lessons Learned about Modeling Collaboration:**
  - R & D still in progress, lessons only beginning to be identified

Tentative Reference Architecture for Modeling Collaboration



Conclusions

- Cognitive models of collaboration can be built
- “Homunculi” and mental telepathy not required
- Complicated task inferencing not required
- Relatively simple requirements
  - Need explicit shared understanding of:
    - Roles
    - Expectations
  - Need expertise to do your own job
    - Heuristics incorporate implicit shared understanding of:
      - Normal team work flow
      - Communications patterns
      - Responsibilities
      - Capabilities of each others’ workstations (e.g., “who can do what”)
      - Time constraints